TOWNSHIP OF ESQUESING

TOWN OF ACTON

BEARDMORE TANNERY SPRAY OPERATION

SPECIAL INVESTIGATION

ALLEGED GROUND WATER CONTAMINATION

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INTRODUCTION

In response to a request from the Division of Sanitary Engineering, the Division of Water Resources initiated an investigation to determine the cause of ground-water pollution in the vicinity of Acton where Beardmore and Company Limited disposes of tannery wastes by spray irrigation. Included in the request was specific mention of the contamination of a private well supply of Mr. K. Breen, to which particular attention has been directed.

On August 4, 1970, the Division of Industrial Wastes indicated that Beardmore and Company Limited were considering establishing a series of test holes to determine the pattern of the movement and the quality of ground water in the area. The Division of Water Resources was requested to review the hydrogeologic conditions in the vicinity of the spray operations to give guidance to the company in the development of this program. Because of the similarity of the two requests, a single, inclusive report has been prepared to evaluate all aspects of this pollution problem.

The investigations have included a review of geologic reports and pertinent literature dealing with past

operations of the Beardmore Tannery and the apparent effects on ground-water quality in the area. Hydrogeologic conditions in the area were determined from field investigations and office studies of water-well records. Field work included the sampling of wells, streams and ponds in the area; levelling and stadia traverse to determine as accurately as possible the direction of ground-water movement; and interviews with local residents and company officials.

The general location of the study area and well locations are shown in Figure 1. A summary of the available well records is shown in Table 1. The well-numbering system used pertains to the permanent coding numbers of the OWRC. Locations sampled for water quality have been given an alphabetical designation to simplify graphic illustrations.

In this report the hydrogeology and the hydrochemistry of the area are summarized. Conclusions are drawn which indicate the source of contamination, and alternatives are presented for providing potable water to individuals whose supplies have been polluted. Recommendations are made regarding further monitoring in the area and use of the Marshall farm for spray irrigation.

BACKGROUND

The disposal of tannery wastes near the southern limits of the town of Acton by Beardmore and Company Limited,

has been a controversial issue which dates back to 1930 when the first complaint of pollution was recorded. The most serious incident occurred in 1946, when a dam holding back tannery waste effluent broke and caused severe flood damage. As a result, the tannery began a program of disposing of its wastes by spray irrigation on nearby pasture lands. This method, however, has also had drawbacks, which have included complaints of odour, reports of paint discoloration on houses in the area and alleged ground-water pollution.

Background information on Beardmore Tannery's waste-disposal method and problems pertaining to local ground-water pollution is presented below.

Composition of Effluent

Beardmore and Company Limited employs two tanning processes: vegetable or sole leather tanning, and chrome or upper leather tanning. A liquid of the following approximate composition would be expected if waste effluents from the various stages of the process are mixed:

Total solids	-	10,000 ppm
Suspended solids	-	4,000 ppm
Dissolved Solids	-	6,000 ppm
BOD - 5 days	-	600 ppm
pH	-	9.0 - 10.5

The major constituents of the suspended solids are calcium hydroxide and calcium carbonate. Sodium chloride is the major component of the dissolved solids.

The effluents from all waste streams of the tannery are mixed, except that from the vegetable tanning section. The total wastes from the tannery amount to approximately 100 million Imperial gallons per annum. This effluent flows through two primary sedimentation ponds where the suspended solids concentration is decreased to approximately 500 ppm. Further storage in secondary ponds reduces the concentration of suspended solids to approximately 200 ppm. The effluent is then sprayed on the fields.

The effluent from the vegetable tanning process is handled separately. It is a dark, reddish-brown liquid that is toxic to plants. This waste is pumped to large storage ponds and then to several shallow evaporation ponds. From there it is pumped to the top of a contour-ploughed, sloping field and allowed to flow downhill where seepage and evaporation reduce its volume. Occasionally, it is also sprayed on the fields.

Ground Water Contamination

In 1947, Beardmore and Company Limited began to apply their effluent in spray form on plant property east

of Highway 25. One consequence of this waste-disposal program was the alleged chloride contamination of South Springs, which was once a source of municipal supply for the Town of Acton. The location of the springs is shown in Figure 1. Chemical data indicate that the chloride concentrations in South Springs increased from 11 ppm in 1955 to approximately 1,200 ppm in December, 1958. At that time, the Town of Acton abandoned these springs as a source of water supply.

In 1961, Beardmore and Company Limited purchased the 90-acre Marshall farm located south of the plant and west of Highway 25 in lot 25, concession 2, Township of Esquesing, for the purpose of expanding the spraying operations. Shortly after the spraying was initiated on this farm in 1961, the chloride concentration in several domestic wells in the area began to increase. Throughout the last quarter of 1961, the K. Breen well water (well 782 or G, Figure 1) had chloride ion concentrations of 7 to 20 ppm. By April, 1962, the chloride concentration had begun to increase and in July, 1963, had reached 340 ppm. The chloride concentration in the K. Breen well water on August 18, 1970, was 720 ppm. The history of the chloride concentration in the water from the K. Breen well is graphically portrayed in Figure 2.

GEOLOGY

Location

The location of the area of study is shown in Figure 1. Although some investigative work was carried out throughout the area, it was primarily concentrated southeast of Acton. Of significance is the fact that the primary area of study is located along a re-entrant of the Niagara Escarpment.

Topography

Elevations in the area range from 1,325 feet above mean sea level in the extreme northwest corner of the study area, to approximately 1,075 feet along the valley of Black Creek. The total relief in the area is about 250 feet.

Regionally, the area is a rough, irregular plain that slopes gently southward. The Marshall farm and the primary study area, shown in Figure 1, are located on a rough plain that in part reflects the shape of the bedrock surface. This surface slopes northeastward towards Black Creek and the Acton re-entrant in the Niagara Escarpment. The topography of the spray area closest to the Beardmore plant and the area of the holding and settling ponds is hummocky, due to local kame-type deposits of sand and gravel. Local relief is generally less than 50 feet, except at the Acton re-entrant in the Niagara Escarpment, where the relief is about 100 feet.

Bedrock

Rocks of Ordovician age lie at depth and are not exposed in the area. Red shale or mudstone of the Queenston formation may subcrop beneath the overburden sediments which fill the Acton re-entrant of the Niagara Escarpment.

The oldest exposed rocks in the area comprise dolomites of the Amabel Group of formations of Middle Silurian age. The Amabel Group comprises porous, highly-fractured, crystalline dolomites and contains numerous biohermal reefs. The Amabel Group attains a total thickness of about 100 feet in the area. There is no evidence of tectonic disturbance of the bedrock and local tilting of the beds can be attributed to depositional dips over the biohermal reefs.

An example of a reef structure in the dolomite is evident south of Acton near Highway 25. The reef trends in a north-south direction in the vicinity of the Marshall and K. Breen farms. The structure is highly fractured and very porous.

A major bedrock valley, termed the Acton re-entrant to the Niagara Escarpment, lies beneath the valley of Black Creek. The depression was likely formed by glacial scouring.

Overburden

The overburden consists of glacial deposits of Pleistocene age which vary from zero to greater than 170

feet in thickness. The large variation in overburden thickness is caused in part by the partial infilling of the Acton re-entrant with glacial sediments in which the total depth of overburden is unknown. In other areas, erosion has exposed the bedrock surface.

The Galt moraine, which is a rugged, stony ridge of loose, sandy glacial till, occurs north of Acton. South of Acton, and south of the spray area, drumlins lie partially buried by till moraine. In the immediate area of the tannery the topography is very hummocky due to the presence of a large number of kames comprised of sand and gravel. Glacial spillways traverse the area and are marked by gravel terraces. One of these outwash gravel deposits covers a part of the Marshall and K. Breen farms between outcrops of the Amabel Group.

Soils

Regionally, the soil type of the area is the Dumfries loam. It exhibits good drainage and an exceedingly stony surface. The parent material is the underlying sandy till or sand and gravel. The stony material is mainly dolomite, presumably from the underlying Amabel Group.

HYDROLOGY

Surface Water

The spray irrigation area is located within the

Black Creek drainage system. There is a general lack of tributary water courses because of the good drainage characteristics of the Dumfries loam. As a result, a large percentage of any precipitation or irrigated water falling on the soil is transmitted through the soil profile, to be eventually discharged to Black Creek as ground-water discharge or baseflow.

The ground surface in the vicinity of the Marshall farm slopes gently southwestward to a swampy area about one mile west of Highway 25. This swamp is drained by a small creek which flows during wet seasons in a northerly direction and traverses the K. Breen farm to a larger swamp, which, in turn, drains to Fairy Lake and Black Creek.

The land surface near the primary spray acreage, east of Highway 25, slopes in a northeasterly direction. Any surface-water runoff from the spray area flows northeastward in a gully which bisects the area. This gully is topographically much lower than the surrounding land and would tend to be a discharge area for any shallow ground-water flow systems in this area. Flow from the gully is to Black Creek.

Ground Water

The overburden at the spray irrigation sites is highly permeable but is essentually unsaturated under natural conditions. The Amabel bedrock, which underlies the area, is

renown throughout many sectors of the Province for its favourable water-yielding properties and displays similar properties in the study area. Domestic wells and the Acton municipal wells, obtain water mainly from this formation.

In the bedrock, ground water moves through interconnected openings such as fractures, joints and bedding planes. It moves under the influence of gravity from areas of high topographic elevation toward discharge in areas of low topographic elevation such as the creeks and swamps in the area.

The general direction of ground-water flow in rock aquifers can be derived by constructing contours on the piezometric surface from the elevations of the static water levels in wells. During this investigation, efforts to obtain these data were hampered as wells were inaccessible, and precise static water levels could not be measured. The piezometric surface of the area, constructed from static water-level data reported when the wells were drilled, is shown in Figure 3. Piezometric contours are lines of equipotental or equal hydraulic head in the aquifer. Ground water moves down-gradient at right angles to the contours.

In the figure, it can be seen that the general direction of ground-water movement is in a northern direction toward Black Creek and Fairy Lake. In the vicinity of the

Marshall farm spraying site ground water moves toward the K. Breen property. In the vicinity of the primary spray site, ground water flows in a northeastward direction toward South Springs and Black Creek.

The direction of ground-water flow shown in Figure 3 could be altered locally by factors such as topography, permeability, spray irrigation and well pumping. For example, daily spraying of large quantities of wastes could superimpose a ground-water mound on the natural ground-water flow patterns and accentuate the hydraulic gradient between the Marshall farm spray area and the K. Breen well. A similar effect could exist between the primary spray area and the South Springs. Also, pumping could induce the flow of pollutants toward wells against the prevailing natural direction of ground-water flow.

WATER QUALITY

General

The effect of the present Beardmore spray irrigation operation has been studied, at times in detail, over the past 12 years. During this investigation, a broad sampling program was undertaken in the vicinity of Acton to determine the general chemical characteristics of ground water in the area and the extent of any ground-water pollution in the

vicinity of the tannery. In addition, analyses of water from wells in similar hydrogeologic environments beyond the Acton area were examined to determine the regional concentrations of chlorides in the ground water.

Samples of water from wells, streams, and ponds in the area were collected for chemical analyses on August 17, 18, and 19, and on October 26, 1970. The results of these analyses are shown in Table 2. In addition to other chemical data, Beardmore provided the results of a sampling and analysis program in which monthly samples were obtained from the Marshall and K. Breen farm wells. The results of the analyses are shown graphically in Figure 2.

An examination of the chemical analysis data contained in Table 2 shows that several wells in the vicinity of the tannery's spray irrigation operations, wells numbered 781,D; 782,G; 783,F; 5,E; and 857,H; have large concentrations of chlorides, sodium and sulphate.

There are several potential sources of these chemicals including natural concentrations in the ground water, septic tank effluents, salt spreading on nearby roads and the spray irrigation of industrial wastes on the Beardmore properties. The latter potential source is of course the most prominent.

The chemical analysis of the spray effluent is shown in Table 2. It can be noted that the wastes also contain large concentrations of chloride, sodium and sulphate as well as chromium and tannins, at 1853 ppm, 1345 ppm, 724 ppm, 0.40 ppm and 30 ppm, respectively. Chromium and tannins are more or less immobilized in soils by adsorption; however, chlorides, sodium, and sulphates are mobile in ground water to varying degrees.

The following sections of this report pertain to the chemistry of chlorides, sodium and sulphate, their natural occurrence, and their presence in the ground water and surface water in the Acton area.

Ground Water Quality

Chloride

Occurrence and Chemistry of Chloride in Water

Chlorides are widely distributed in natural waters. They are found in sedimentary rocks deposited in marine environments. During deposition, the rock becomes impregnated with soluble salts and chloride is present as a part of sodium chloride crystals or in solution in interstitial water as the chloride ion.

Fine-grained marine shales that characteristically have small permeabilities, retain chlorides for very long

periods of time, while outcropping, fractured and porous carbonate rocks, through which ground water percolates and leaches salt from the interconnected pore space, would not be expected to retain large amounts of chlorides.

The circulation of chloride ions in the hydrologic cycle is largely through physical processes. Chloride ions in natural waters do not readily enter into oxidation or reduction reactions, do not form important ion complexes, do not form insoluble or slightly soluble salts, are not significantly adsorbed on mineral surfaces, and do not enter into biochemical reactions. Because of these factors, chloride ions move with the water through most soils with less retardation or loss than any other chemical. However, because the ion is physically large, its movement through compacted clays and shales may be retarded.

Chloride ions are present in all natural waters, but generally the concentrations are small. Rainwater falling near oceans commonly contains from 1.0 ppm to several tens of ppm of chloride, but the observed concentrations generally decrease in a landward direction. The average chloride concentration in rainwater over the United States is only a few tenths of a ppm. In most surface streams, chloride ion concentrations are relatively small. Exceptions occur where streams receive inflows of ground-water or industrial waste with large chloride concentrations.

Chlorides in drinking water are generally not harmful to human beings unless large concentrations are reached, although relatively low chloride concentrations may be injurious to some people suffering from diseases of the heart or kidneys. Restrictions on chloride concentrations in drinking water are generally based on palatability rather than on health factors. The maximum recommended limit for chlorides in municipal water supplies in Ontario is 250 ppm, "OWRC Guidelines and Criteria for Water Quality Management in Ontario, 1970".

Chloride in water can be tasted by most people at a concentration level of 550 ppm. Water containing more than 500 ppm may be unpalatable and cause appetite disturbances. Although an excess of chloride induces thirst or can act as a diuretic, water containing up to 1400 ppm has been used by some communities for many years without appreciable harm.

In addition to the palatability and the possible hazard to health, chlorides are strong contributors to the rate of corrosion of metals.

Regional Chloride Concentration in Ground Water from Middle Silurian Aquifers near Acton

Water-quality data compiled by the Division of Water Resources indicates that naturally occurring concentrations of chloride in Middle Silurian aquifers in the Acton region are low. These data are summarized as follows:

Report Area	Chloride Concentration (ppm) range	average
Campbellville-Nassagaweya Twp.	3 to 11	6.2
Guelph-Wellington County	3 to 35	17.3
Rockwood-Eramosa Twp.	4 to 12	8.1
Belwood Lake-West Garafraxa Twp.	8	8.0
Orangeville-Caledon Twp.	6 to 7	6.5
Overall Average		9.2

These data represent average values of chloride concentrations found in 28 wells throughout the region.

In addition to the above, well logs on file with the Division of Water Resources were examined for wells completed in Middle Silurian aquifers in the townships of Esquesing, Nassagaweya, Erin and Eramosa. Water-well records are available for 1,346 bedrock wells. None of the wells were reported by drillers to produce salty water.

Chloride Concentrations in the Acton Area

The average chloride concentration in the waters from wells beyond Beardmore's spraying operations was 14.1 ppm for the samples collected in August, 1970. This contrasts with an average concentration of 474 ppm of chloride for sampled wells D, E, F, G, and H, located in the vicinity of the spraying sites. The chloride concentration in the spray effluent was 1,853 ppm. Additional water samples collected on October 26, 1970, had average chloride concentrations of 15.4 ppm and 341 ppm in the unaffected and contaminated wells,

respectively. Of the wells sampled in August and October, three wells, well D, F, and G, produced water with unacceptably large concentrations of chloride, i.e., in excess of 250 ppm.

In Figure 4, isochlors have been drawn which join points of equal chloride concentration for samples collected on August 18, 1970. To minimize assumptions in the analysis, the chloride concentration of the waste has not been plotted on the figure. Examination of the figure shows that the focal point of the large chloride concentrations is on the properties used by Beardmore for its spray irrigation disposal. A similar figure, drawn from the October 26, 1970 chemical data, is not presented in this report but shows a similar configuration.

Figure 2 shows a graph of the chloride concentrations in the K. Breen and Marshall farm wells from September, 1961, to December, 1970. Notation is made on the figure of the start of spraying on the Marshall farm. Initially, the chloride concentration in the K. Breen and Marshall farm wells varied from 7 to 20 ppm, which is similar to the chloride contents in the water from other wells in the Acton area which are not polluted. Approximately seven months after the spraying of tannery effluent was initiated, upgradient from the wells, a sudden increase in chloride concentration

to about 100 ppm was observed. Approximately 2½ years after spraying began, the concentrations of the chloride in the ground water near the Marshall farm attained the present level of 700 to 1,000 ppm. This pattern of ground-water contamination is identical to that of the contamination of South Springs which is discussed in the section, "Surface Water Quality".

Sodium

Occurrence and Chemistry of Sodium in Water

The occurrence of sodium is similar to that described for chloride. Sodium may be present in sedimentary rocks as crystals of readily soluble sodium salts or in ionic form in aqueous solutions. In these forms, sodium may be flushed from permeable rocks by ground-water flow. The fresh-water bedrock aquifers near Acton have little natural sodium content according to analyses performed by the Ontario Department of Mines and Northern Affairs.

Sodium ions, unlike chloride ions, may be removed from solution by adsorbtion on minerals with high cation exchange capacities, such as clays. Such reactions usually result in the release of calcium which consequently increases the hardness of the water. Because sodium can be adsorbed, it is not as good an indicator for tracing ground-water movement as chloride.

All natural waters contain measureable amounts of sodium. Natural concentrations range from about 0.2 ppm in rain and snow, to more than 100,000 ppm in the brines from very deep bedrock formations.

Sodium concentrations in excess of 200 ppm in drinking water may be harmful to persons suffering from cardiac, renal and circulatory diseases. It has been reported that drinking water of good quality may contain up to 115 ppm Na, although others have recommended a limit of 10 ppm as desirable.

Regional Sodium Concentrations in Ground Water from Middle Silurian Aquifers beyond the Acton Area

Analysis for sodium in water is seldom performed on a routine basis; hence, there are no regional data on sodium concentrations in the Middle Silurian aquifer. Based on regional chloride data, the natural sodium content of the ground water in the area is likely small.

Sodium Concentrations in Water in the Acton Area

The average sodium concentration in the water from uncontaminated wells was 8.2 ppm for samples collected in August, 1970. This contrasts with an average concentration of 301 ppm of sodium for sampled wells D, E, F, G, and H, near the spraying operations. The sodium concentration in the

spray effluent was 1,345 ppm. Additional water samples collected on October 26, 1970, had average sodium concentrations of 12 ppm and 207 ppm in the unaffected and contaminated well supplies, respectively.

In Figure 5, lines joining equal concentrations of sodium have been drawn for the samples collected on August 18, 1970. As in the case of chloride, the sodium concentration of the sprayed wastes has been omitted from the figure. Examination of the figure shows that the focal point of large sodium concentrations in the ground water is near Beardmore's disposal operations. Data from the October 26, 1970 sampling show a similar configuration.

Sulphate

Occurrence and Chemistry of Sulphate in Water

The most extensive and important occurrences of sulphate are in evaporite sediments. Calcium sulphate, in the form of the minerals gypsum and anhydrite, makes up a considerable part of many evaporite rock sequences. These minerals are soluble in water to some degree.

OWRC standards recommend that sulphate concentrations do not exceed 250 ppm and it is desirable that they be less than 50 ppm. Public water supplies with sulphate contents above this limit are used without adverse effects.

It has been reported that concentrations of 1,000 ppm of sulphates in water are harmless; however, other sources report that a litre of water containing 1,000 to 2,000 ppm of sulphates may be injurious to health.

Regional Sulphate Concentrations in Ground Water From Middle Silurian Aquifers Beyond the Acton Area

Like sodium, sulphate concentrations are seldom determined on a routine basis and the regional chemical quality of ground water with respect to sulphate cannot be reliably defined. Throughout the Acton region, sulphate concentrations are generally expected to be low in ground water which is typical of the Middle Silurian aquifers in other outcrop areas. Local pockets of high concentrations, however, can occur.

Sulphate Concentrations in the Acton Area

The average sulphate concentration in the uncontaminated ground waters of the area was 50 ppm for the samples collected on August 17 and 18, 1970. This contrasts with an average concentration of 198 ppm for the contaminated sampled wells D, E, F, G, and H. The sulphate concentration in the spray effluent was 724 ppm. Additional samples were collected on October 26, 1970, with average sulphate concentrations of 58.5 ppm and 152 ppm in the unaffected and contaminated wells, respectively.

Figure 6 shows lines of equal sulphate concentration for samples collected on August 18, 1970. The focal point of the large sulphate concentrations in the ground water is near Beardmore's disposal operations. As in previous discussions, data for the October 26, 1970 sampling show similar results.

Piper and Schoeller Chemical Plots

Chemical relationships between waters from various sources can often be determined by presenting chemical data in graphical form. Such methods include Piper and Schoeller chemical plots which are presented in figures 7 and 8, respectively.

The Piper plot is a trilinear diagram which illustrates the percentages of major anions and cations in the water samples. Anions and cations are shown separately in two triangular fields and are combined in a diamond-shaped field. Trilinear diagrams are useful in pointing up differences or similarities between waters and can also show the effects of mixing between waters. Mixtures of two different waters will plot as points on a straight line between end points which represent the two water types. In Figure 7, the end points are natural ground water and the spray effluent.

Figure 7 shows a Piper plot for the August, 1970, chemical data. Natural ground water in the unpolluted wells is of the calcium-bicarbonate type. The spray effluent shows

the strong concentrations of sodium and chloride. Five wells, D, E, F, G, and H, produced a mixture of the two water types, with the concentration at each well reflecting the distance from the spray irrigation site. As shown, a nearly straight line can be drawn from sample N, the spray effluent, through the suspected contaminated wells D, G, E, F, and H, to the uncontaminated wells. This is particularly true of the chloride plot as the ion moves freely with ground water. This indicates that wells D, G, E, F, and H represent a mixture of the uncontaminated ground water and the spray effluent.

The distinction between the two basic water types is emphasized further in the Schoeller plot shown in Figure 8. The waters from wells D, E, F, G, and H, have characteristically different plot shapes than the uncontaminated wells, and show progressively larger concentrations of Na, Cl, and SO_4 from E to D. The plot shows that contamination of the ground water decreases with distance from the Marshall farm spray irrigation area through well D, the Marshall farm well; well G, the K. Breen well; well F, the J. Breen well; well H, the J. Bruce well; and well E, the J. O'Rourke well.

<u>Surface Water Quality</u>

Streamflow consists of two main hydrologic components, namely, surface runoff and ground-water discharge. It is the latter that sustains streamflow during periods of non-precipitation.

The role of ground water in the hydrologic cycle in that it forms a major portion of streamflow is seldom appreciated. The pollution of ground water with highly mobile chemical ions such as chlorides, can cause a deterioration in surface-water quality. In cases where streamflow is large and the input of pollutants into the ground water is small, the effects on surface-water quality may be imperceptible. In cases where streamflow is small, such as in headwater areas, and the input of pollutants into the ground water is large, the effects on surface-water quality can be drastic. With this relationship in mind, the quality of surface water in the Acton area was examined to determine the effects of the Beardmore operation on the water quality.

At various times in the past, surface-water samples have been collected from several locations in the Black Creek basin. Figure 9 shows the locations of these sampling points and Table 3 summarizes the results of chloride analyses for samples collected by the Division of Sanitary Engineering in 1963 and 1964, and by the Division of Water Resources in 1970. These data were not related to streamflow and consequently contain some minor discrepancies; none-the-less, they are revealing.

Normal chloride concentrations in the surface water in the Acton area are characterized by the quality of the

tributary stream at station 8 (Figure 9), and of Black Creek near Fairy Lake, station 1A, which contain about 28 ppm of chlorides. The chloride level in Black Creek increases to greater than 250 ppm in its course past the Beardmore operation. There is an additional chloride input into the creek from the sewage treatment plant of about 60 ppm to 110 ppm which is a typical chloride concentration for this type of operation. The data clearly show that the treated sewage effluent discharge dilutes the chloride concentration in the creek between stations 1 and 2. As the chloride concentration in unpolluted ground water, which discharges to the creek, averages only about 15 ppm, and the treated sewage effluent contains only 100 ppm, the high chloride levels in the creek can be attributed to Beardmore's spraying operation. The effects on the surface-water quality persist beyond station 10 near Stewartown where the chloride concentration was about 150 ppm.

The chloride concentrations in Black Creek are not stable, but rather, they appear to have been increasing over the past five years. Data to support this observation are shown in Table 4, which summarizes chloride concentration data from a monitoring station on Black Creek at the 3rd line in the Township of Esquesing. Although these data have not been related to flow in the creek, it appears that the average chloride concentration at the monitoring station

has increased from 156 ppm to 300 ppm. The cause of the increasing chlorides can be attributed to either an unstabilized, polluted ground-water discharge or an increase in spray effluent loading with time. Because of the length of time that spraying has been carried out, the proximity of the spray site to the creek and the small area involved in Beardmore's spray operations, it is likely that the latter is the case. Therefore, it appears that chloride concentrations in Black Creek, and consequently the potential use of the water, will be dependent on the amount of effluent discharged by Beardmore and Company.

Data are presented in Table 5 which indicate that the chloride concentration in South Springs at one time was about equal to that of water produced from the unpolluted aquifers in the area. That is, background chloride concentrations in the ground water averaged 14 ppm, while the South Springs chloride concentration was 11 ppm.. The present chloride concentration of South Springs is approximately 800 ppm. The rapid increase in concentration of chloride in the spring water between July, 1955, and December, 1957, is similar to that observed in the K. Breen and Marshall farm wells after spraying was initiated on the Marshall farm. The chloride concentration in the spring is indicative of concentrations in the ground water discharging to Black Creek.

Livestock watering and crop irrigation are the two major uses of the creek downstream from Acton. From literature and from "OWRC Guidelines and Criteria for Water Quality Management in Ontario, 1970", the limiting concentrations of chloride for livestock watering and crop irrigation are 1,500 ppm and 150 ppm, respectively. Therefore, from the data in tables 3 and 4, it is apparent that the use of Black Creek for irrigation purposes has been largely lost, at least to Stewartown, six miles downstream from the Beardmore operation.

DISCUSSION AND CONCLUSIONS

Spray operations of liquid industrial wastes by Beardmore and Company Limited near Acton have been carried out on a topographically rough plain that slopes towards Black Creek. The overburden in the area is a sandy, glacial till, with the Marshall farm area having a thin outwash gravel deposit over the bedrock. Highly permeable dolomite of the Amabel Group of formations underlies the area. These conditions are ideal for a large volume spray operation from the point of view that the large quantities of

effluent generated by the Beardmore operation (100 million gallons annually) can be successfully sprayed on a relatively small acreage without inducing large-scale runoff or ponding. However, because the sprayed effluent readily enters the overburden and infiltrates into the bedrock, it also contacts the ground-water body relatively quickly with little loss of volume through runoff or evapotranspiration.

Ground-water supplies in the area are primarily found in the Amabel Group of formations which forms one of the best bedrock aquifers in Ontario. A map of the piezometric surface shows that the general direction of ground-water movement in this aquifer is from the Marshall farm toward the K. Breen well and from the primary spray area toward South Springs.

The Beardmore spray effluent has high concentrations of sodium, sulphate and chloride. An analysis of the quality of ground water from private wells down-gradient from the spraying operations indicated that these waters are also abnormally high in sodium, sulphate and chloride. The regional quality of water drawn from the Amabel aquifer, in townships surrounding the Beardmore operation, was studied, and of the hundreds of well records inspected, none of the wells were reported to produce salty water by the drillers. Of the wells sampled during this survey, only the five

wells down-gradient from the Beardmore spraying operations produce salty water. Isoconcentration maps of chloride, sodium and sulphate in the ground water were constructed and the anomalous well waters proved to be grouped down-gradient from a focal point of poor quality water centered at the Beardmore spray operations. Further, analysis of Piper and Schoeller chemical plots for well waters in the area has shown that the affected wells contain mixtures of Beardmore spray effluent and natural ground water in proportions related to the distance from the spray operation.

Clearly, the Beardmore waste effluent gains access to the bedrock aquifer and mixes with the natural ground water in the area, producing waters of varying chemical characteristics dependent upon the degree of mixing.

Other sources of contamination which have been suggested by Beardmore can be discredited. Road salting as a source of chlorides is possible; however, other wells in the area do not exhibit chloride contamination despite similar well constructions, set back distances from the highway and aquifer characteristics. Also, road salting would not account for the presence of abnormally high sulphate concentrations in the affected wells. Natural sources of contamination have been cited as having possibly caused this

problem; however, after inspecting 1,346 well records in the area, after studying several ground-water investigations for municipalities in the same hydrogeologic environment, and after analysing water samples collected from unaffected and affected wells in the Acton area, it is concluded that no natural source of contamination has produced concentrations of sodium, sulphate and chloride at the levels found in the wells down-gradient from the Beardmore spray operations. Finally, it has been suggested that septic tanks may have caused the problem. Septic-tank effluents rarely contain greater than 80 ppm Cl and therefore would not cause chloride levels in the order of 1,000 ppm, as observed in the polluted wells. Further, the Police Village of Rockwood is situated in a similar hydrogeologic environment and has experienced pollution of private wells from septic-tank effluents. However, the chloride concentrations in the Rockwood supplies seldom exceed 10 ppm.

In considering the occurrence and chemistry of chloride in water it is found that chloride moves through most soils with less retardation or adsorption than any other chemical. It is virtually not found in rain water nor is it expected to be found naturally in water flowing through shallow, fractured carbonate rocks. However, because of the Beardmore spray operations, ground water near

Acton is contaminated to the point of being unpalatable and may be a hazard to health.

Beardmore has provided data on the concentrations of chlorides in wells when spraying was initiated at the Marshall farm. These data are plotted in Figure 3 and show that the natural chloride content in the ground water was about 10 ppm prior to spraying. This conforms with the drillers' logs for the K. Breen, Marshall and Bruce wells which reported that the water was fresh when the wells were constructed. After about seven months of spraying operations at the Marshall farm, the chloride concentrations in the ground water at the K. Breen and Marshall wells began to increase. Concentration levels rose rapidly to unacceptable limits. On October 26, 1970, the chloride concentrations were 699 and 511 ppm in these wells, respectively. Spraying was terminated in the spring of 1970. Provided that further spraying does not take place on the Marshall farm, it is anticipated that natural hydrologic processes will eventually restore the polluted wells to their original quality. It is evident, however, that this will take a long time as the chlorides have remained at high levels in the polluted wells. This may be due to the presence of residual chlorides in the sprayed soil which are now slowly being leached by rainfall.

During 16 years of irrigation on the prime spraying area, the K. Breen and Marshall wells were unaffected by the waste effluent. However, during this time, the spring which served as Acton's municipal system became polluted. The major difference between the two spray sites is that the prime irrigation area is down-gradient from the affected wells, while the Marshall farm spray area is up-gradient from the affected wells. Waste discharged on the Marshall area has the potential to move toward the Marshall and Breen wells, possibly via a biohermal reef which appears to trend between the wells. Such areas of relatively high permeability could rapidly transmit waste to the underlying fresh-water aquifer. In addition, pumping of the down-gradient wells could accelerate the transmission of the waste water.

Historical chemical data in the area show that well contamination of the K. Breen, O'Rourke, Marshall, Bruce and J. Breen wells has been caused by the spraying operation at the Marshall farm site, and therefore, this site is unacceptable for spray irrigation operations. There does not appear to be any evidence to suggest that spraying at the prime irrigation site interferes with well-water quality, however, spraying on the prime site has polluted the South Springs and Black Creek.

Black Creek has received ground-water discharge laden with waste effluent and consequently, there has been a marked deterioration in surface-water quality. Chloride concentrations in Black Creek over the past five years have doubled, reaching an average concentration of 300 ppm at a sampling point immediately downstream from the Beardmore spray operations. This pollution of Black Creek has restricted the use of the stream for irrigation for a distance of at least six miles downstream. Further spraying or increased effluent loadings by Beardmore will only increase chloride levels in Black Creek.

ALTERNATE WATER SUPPLIES

There are several methods which could be attempted to restore water to those affected by the spraying operations. These alternatives include:

(1) Water can be hauled to the affected residences. This would necessitate the provision of storage facilities at each site. The existing wells are not suitable for this purpose.

(2) Reverse osmosis treatment equipment could be installed to treat the well-water supplies.

(3) The possibility of connecting the affected parties to the Acton municipal water supply system could be investigated.

(4) A communal well could be drilled in a remote area, and water could be piped to the affected residences.

RECOMMENDATIONS

(1) A test-drilling and piezometer-construction program, to determine ground-water flow patterns and ground-water quality in the area, has been suggested by Beardmore and Company Limited. This work is not required as existing data show that Beardmore's waste disposal program has impaired ground-water and surface-water quality in the vicinity of their spray-irrigation sites.

(2) The Marshall farm spray-irrigation site is unacceptable for waste disposal, and its future use is not recommended.

All of which is respectfully submitted,

Prepared by: F. R. Campbell, M. Sc.,
Geologist,
Surveys and Projects Branch.

FRC/1b
30/09/71

T. J. Yakutchik
....
T. J. Yakutchik, Supervisor,
Surveys and Projects Branch,
Division of Water Resources.

TABLES

ONTARIO WATER RESOURCES COMMISSION

AREA OF SURVEY ACTON

P1 COUNTY HALTON

TABLE OF WATER WELL RECORDS

TABLE 1

DATE AUG 6/70

RECORDER S SISSON

Well No.	Location TWP OF ESQUESING ELEV FROM TOPO MAP	CON	LOT	Owner	Driller	Well Type	Well Diameter INCHES	Depth FEET	Static Level FEET	Pumping Rate GPM	Pumping Level FEET	Quality	Use	Remarks, Log, etc.
706	1195 1200.	1	32	STANLEY CONST	CHAS HILL.		4.	78	17.	5	40	S	D.	0 cl stns 20 gr, stns 42 42 ls 78 *7
695	1210 1200	1	32.	GORDON CLOW.	J.R. SPROWL.		4¼	89	57.	6.	60	FR.	D.	0 sd 6 bldr, gr, cl 53 53 ls 89 *79 82 85
696	1190 1200	1	31	EVALINE HEPBURN	J.R. SPROWL		4¼	81	51	5	55	FR.	D	0 csegr 10 sd 30 sd, marl 53 53 ls 81 *6 75
793	1205 1200	II	31	JOHN KINGSBURY	J.R. SPROWL.		4"	99	65	10	65	FR.	D.	0 cl, gr 40 & sd 72 72 ls 99 *85 95
689	1210 1200	1	27	RAY POST	J.R. SPROWL		4½	126	80	5	90	FR.	D S	0 ts 1 bldr 10 csegr, cl 60 60 ls 126 * 12
684	1175	1	26	SOPHIE CYGANIK	J.R. SPROWL		4¼	68	4	7.	43	FR.	D.	0 ts 2 ls 68 *2 59 6
785	1180 1175	II	28	UKRAINIAN NATL FED	J.R. SPROWL		5½	97.	20	30	40	FR	P D	0 cl, stns 15 cl, gr 35 35 ls 97. * 7 8 9
784.	1150	II	27	JOHN McMULLEN	J.R. SPROWL.		4½	54.	6	20	10	FR.	APT. D.	0 loam 2 stns 10 gr, sd, cl 26 26 ls 54. * 4 4
680.	1175	I	25	MELVIN BARBER	J. O'ROURKE		5.	52	10	10	20	FR	D.	0 ls 52. *30 50
682.	1175	I	26	KEN ESCH.	J.R. SPROWL		4.	93½	15	7.	35	FR.	D	0 brn sh. 2 ls 93½ *35 72 90
.	1175 TOWN			ACTON PUC	J.L. GRAHAM.		10	65	FLOW 5gpm	43.	60	FR.	MUN	0 ts 2 cl 16 sh sh 65 *30 60
	1180 TOWN			MASALES DAIRY	J.R. SPROWL		5⅝	80	15	30	25	FR.	COM. D.	0 old well 30 ls 78 78 sh 80 *3 6 7 78

P2

ONTARIO WATER RESOURCES COMMISSION

TABLE OF WATER WELL RECORDS

AREA OF SURVEY ______________________

COUNTY ______________________

DATE ______________________

RECORDER ______________________

Well No.	Location ELEV	CON	LOT	Owner	Driller	Well Type	Well Diameter	Depth	Static Level	Pumping Rate	Pumping Level	Quality	Use	Remarks, Log, etc.	
3.	1170	TOWN		ACTON PUC	J.L. GRAHAM		10	55	4.	50	43	FR.	MUN	0 ts 2 cl 22 gr 23 ls 34 34 sh 55 sh.	*34 53
4.	1172.	TOWN		MICRO PLASTICS	J.R. SPROWL		5.	136	8	25	60	FR.	C. IND.	0 csa sa 22 gsa 40 ls 63 63 sh 116 sdst, sh 136	*6. 85 105 117 125
857	1150	III	26	JOHN BRUCE	J.R. SPROWL.		4.	48	8	20.	-	FR.	D	0 stns & gr 14 ls 48	*8 48.
783.	1150	II	26	JIM BREEN	J.R. SPROWL.		4.	53	8	10	-	FR.	D	0 ts 6. ls 53	*53
782	1150	II.	26	KEVIN BREEN	J.R. SPROWL		4.	44.	7	15	-	FR	D	0 ts 4 ls 44	*4.
779	1150	II	25	LAVERNE SECORD	J.R. SPROWL		4½	58	7	25	12	FR.	APT. D	0 cl, gr 6 ls 58	*21 45 48 54.
781	1175	II	25	BEARD MORE & CO MARSHALL FARM	J.R. SPROWL.		4¼	123	12	15	5	FR.	AGR. IRR?	0 cl bldr. 9 ls. 120 120 soap stn 123	*35 85 48 10 63 12 65
780.	1175'	II	25	GEORGE BEIRNES	J.R. SPROWL.		4½	67	12	3	30	FR.	D.	0 cl 5 ls 67.	*30 60 63
776.	1175'	II	25	CLARENCE SLAVEN	J.R. SPROWL.		4½	49	15	20	15	FR.	D.	0 cl, gr 21 ls 49	*45.
853	1175'	III	24	C.E. CUTTS	J.R. SPROWL.		4	42.	10	10	10	FR.	D S	0 ts 5. dk rk, earth 16. 16 ls 42.	*42
855	1175	III	24	JAMES M. BRANDFORD	J.R. SPROWL.		5¼	103	18	15	26	FR.	AGR IRR.?	0 cl, sd 10. ls 103	*48 65 85 100
6.	1175'	IV	25	McNAIR PRODUCTS	GRAHAM.		10.	120.	9	27	100	FR.	IND.	0 cl, fsd 12. bldr 17 ls 115 115 sh 120	*11

ONTARIO WATER RESOURCES COMMISSION

TABLE OF WATER WELL RECORDS

AREA OF SURVEY ______

P3 COUNTY ______

DATE ______

RECORDER ______

Well No.	Location ELEV	CON	LOT	Owner	Driller	Well Type	Well Diameter	Depth	Static Level	Pumping Rate	Pumping Level	Quality	Use	Remarks, Log, etc.
854	1175	III	24	J.R. PERRY	J. R. SPROWL.	●	4¼	86	20	8	25	FR.	AGR. IRR?	o cl,gr 16. ls 86 * 45 65 85
918	1150	IV	26	R.M. SPROWL	J.R. SPROWL	O	5¼	144	–	–	–	–	T.H	0 stygr 20 sd,gr,cl 45 45 od,gsd 92 sd,cl 144 *45
917	1125	IV	26	J.R. SPROWL	J.R.SPROWL	O	4¼	170	–	–	–	–	T.H.	o ts 4. sd 128 sd,cl 170 PULLED.
913	1100.	IV	24	ACTON L.S. QUARRIES	GRAHAM DRILLING	●	7	80	30	3	60	S	Comm.	0 sdy cl 12 sh. 80 * 78 ABANDONED.
911	1100.	IV	24	C. A. FOSTER.	J.R. SPROWL	●	4.	41	6.	30	0	FR.	D.	o sd,cl,gr. 41 * 41
912.	1150	IV	24	NORM WRIGHT	F.M. DENNIS	●	6⅝	65	5	15	35	FR.	D.	o sd. 35 stns 36 f. sd 60 60 coarse gr. 65. *65

ONTARIO WATER RESOURCES COMMISSION

TABLE OF WATER WELL RECORDS

PA.

AREA OF SURVEY ______ COUNTY ______

DATE ______ RECORDER ______

Well No.	Location ELEV	CON	LOT	Owner	Driller	Well Type	Well Diameter	Depth	Static Level	Pumping Rate	Pumping Level	Quality	Use	Remarks, Log, etc.	
798	1250	II	32	BRUCE MACPHERSON	J.R. SPROWL		4¼	80	39	6	40	FR.	D.	0 cl, gr, bldr. 36. 36 ls. 80.	* 65 72. 76.
873	1275	III	32.	ROBERT HEATLEY	J.R. SPROWL.		4½	81	30	5	45	FR.	D	0 gr stns 25 gum, sd 40 40 sty grs 54 ls 81	* 65 72. 80.
949	1200	IV	31	K.L. ALLEN.	J.R. SPROWL.		4½	70.	2.	4.	70	FR.	D.	0 sd. 4. sty cl, sd 27 27. brn rotten ls 32. ls 65 65 sh. 70.	* 63 65
946	1175	VI.	30	ACTON PCH	J.L. GRAHAM		10.	88	11	33	63	FR.	MUN.	0 ts l cl, stns 12. cl 22 22 ls 24 cl, stns 33 rk. 88	* 65 88
987.	1220.	V	32	J. COLE	J.R. SPROWL		4½	75	FLOW.	2.	75	FR.	D.	0 sd 10. gr, cl 20 20 ls. ~~75~~	* 54 63 72
982.	1165	V	30	W.J. McDONALD	J.R. SPROWL.		4.	50	9.	4	25	FR.	D.	0 dug 5 ls. 50.	* 39 98
920.	1150	IV	28	S. BRAIDA	J.R. SPROWL		4.	59	7	5	47.	FR.	D.	0. sd, gr 49 rk. 59	* 7

TABLE 2

ONTARIO WATER RESOURCES COMMISSION
TABLE OF WATER ANALYSES

AREA OF SURVEY Acton

DATE

Source and Number	Location and Owner	Date Sampled		pH	Mineral Constituents in parts per million (ppm): Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)			Sulphate (SO_4)	Chloride (Cl)	Chromium (Cr)	Tannin (Tan acid)	Nitrate (N)	Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$: Total		Total Dissolved Solids in ppm	5-Day BOD (ppm)	Remarks
Well 798-A	B. McPherson	18/8/70		7.7	88	15	5	1.2			23	13	0.00	0	0.49	237	282		270	0.4	
Well 695-B	G. Clow	18/8/70		7.5	115	5	4	1.7			55	7	0.00	0	0.15	250	308		390	0.4	
Well 696-C	E Hepburn	18/8/70		7.5	112	4	4	1.5			32	11	0.00	0	3.1	249	296		360	0.4	
Well 781-D	Marshall Farm	18/8/70		7.2	249	17	660	2.1			400	940	0.00	0	8.5	385	696		2680	0.4	
"	"	26/10/70					279	1.6			230	511									
Well 5-E	J. O'Rourke	18/8/70		7.4	132	25	63	5.0			74	127	0.00	0	11	262	432		680	0.4	
"	"	26/10/70					40	5.3			53	76									
Well 783-F	J Breen	18/8/70		7.4	157	14	195	7.6			145	339	0.00	0	4.7	258	452		1170	0.4	
Well 782-G	K. Breen	18/8/70		7.4	208	11	455	2.8			280	720	0.00	0	3.7	282	564		1970	0.4	
"	"	26/10/70					472	3.6			240	699									
Well 857-H	J. Bruce	18/8/70		7.3	148	20	133	3.3			81	243	0.00	0	1.7	310	452		940	0.4	
"	"	26/10/70					132	3.6			83	240									

ONTARIO WATER RESOURCES COMMISSION

TABLE OF WATER ANALYSES

AREA OF SURVEY Acton

DATE

Source and Number	Location and Owner	Date Sampled		pH	Mineral Constituents in parts per million (ppm): Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)			Sulphate (SO_4)	Chloride (Cl)	Chromium (Cr)	Tannin (Tan. Acid)	Nitrate (N)	Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$: Total		Total Dissolved Solids in ppm	5-Day BOD (ppm)	Remarks
Well 856-I	McNair Products	18/8/70		7.5	111	9	2	0.8			40	6	0.00	0	0.44	267	312		330	0.6	
"	"	26/10/70					3	1.0			40	6									
Well 780-J	G Beirnes	15/8/70		7.5	98	11	4	0.7			27	14	0.00	0	<0.01	250	288		310	0.6	
"	"	26/10/70					4	0.5			26	15									
Well 855-K	J. Brantford	15/8/70		7.6	94	11	2	0.9			32	3	0.00	0	2.0	243	282		305	0.6	
"	"	26/10/70					2	0.6			29	4									
Beardmore Stream-L	Beardmore & Co.	17/8/70		8.1	54	13	42	2.2			46	41	0.05	0.5	.32	178	196		360	2.5	
Roughed Furrows M	"	17/8/70		6.9	120	24	1780	34			568	3180	1.40	2250	.13	576	400		7930	1,500	
Spray Effluent-N	"	17/8/70		7.6	237	2	1345	11.3			724	1853	0.40	30	.01	421	600		4920	460	
Springs - O	Acton	17/8/70		8.0	96	5	15	1.7			38	35	0.00	0	1.3	195	262		440	3.0	
Well 915-P	Sproule McIsaac	17/8/70		7.6	85	11	11	0.6			29	20	0.00	0	2.5	205	258		350	0.4	
Well 1A-Q	Acton PUC	17/8/70		7.4	128	14	14	2.4			88	26	0.00	0	.78	295	378		520	0.4	

ONTARIO WATER RESOURCES COMMISSION
TABLE OF WATER ANALYSES

AREA OF SURVEY Acton

DATE

Source and Number	Location and Owner	Date Sampled		pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)			Sulphate (SO_4)	Chloride (Cl)	Chromium (Cr)	Tannin (Tan Acid)	Nitrate (N)	Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$ Total		Total Dissolved Solids in ppm	5-Day BOD (ppm)	Remarks
Well 946-S	Acton PUC	17/8/70		7.6	93	13	2	0.6			27	7	0.00	0	1.2	239	286		360	0.4	
Well 854-T	R. Perry	17/8/70		7.4	122	24	14	17.7			65	21	0.00	0	15	312	402		630	0.6	
"	"	26/10/70					15	19.3			69	21									
Well 920-U	S. Brada	17/8/70		7.6	101	4	6	3.3			33	12	0.00	0	.7	217	270		410	1.0	
Well 680-V	M. Barber	17/8/70		7.6	86	14	1	0.2			45	2	0.00	0	.20	231	274		360	0.6	
Well 682-W	K. Esch	17/8/70		7.5	88	16	3	0.5			45	4	0.00	0	.12	242	286		390	0.6	
"	"	26/10/70					3	0.6			45	4									
Well-689-X	R. Post	17/8/70		7.4	103	26	12	0.7			44	19	0.00	0	17	261	356		520	1.2	
"	"	26/10/70					11	0.6			36	16									
Well 785-Y	Smallwood Acres	17/8/70		7.6	86	16	3	0.6			17	8	0.00	0	.44	244	282		360	0.8	

ONTARIO WATER RESOURCES COMMISSION
TABLE OF WATER ANALYSES

AREA OF SURVEY Acton

DATE

Source and Number	Location and Owner	Date Sampled		pH	Mineral Constituents in parts per million (ppm) Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)			Sulphate (SO_4)	Chloride (Cl)	Chromium Cr	Tannin (Tan. Acid)	Nitrate (N)	Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$ Total		Total Dissolved Solids in ppm	5-Day BOD (ppm)	Remarks
Stream I	Above Beardmore Co.	19/5/70		7.7	84	10	15	4.1			27	28	0.00	0	0.88	211	250		400	5.0	
" I	"	26/10/70					12	2.3			41	25									
Stream II	Below Beardmore Co.	19/5/70		7.7	107	11	162	7.8			97	244	0.03	1.5	2.7	222	312		900	11	
" II	"	26/10/70					180	5.8			99	256									

Table 3. Chloride Concentrations in Surface Waters in the Acton Area.

Station	Chloride Concentration - ppm			
	Feb./63	Oct./64	Aug./70	Oct./70
1A	-	28	28	25
1	362	157		
STP	108	63		
2	267	120		
3	815	905	815	770
4	340	254		
4A	326	280		
5	336	270	244	256
6	283	262		
7	200	184		
8	28	-		
9	175	185		
10	132	150		

STP - Sewage Treatment Plant

Source of Data - District Engineers Branch, Division of Sanitary Engineering, OWRC.

Table 4. Chloride Concentrations in Black Creek at the 3rd Line, Esquesing Township.

Year	Chloride Concentration (ppm)		
	Maximum	Minimum	Average
1956-1966	305	5	156
1969	216	181	198
1970	489	142	300

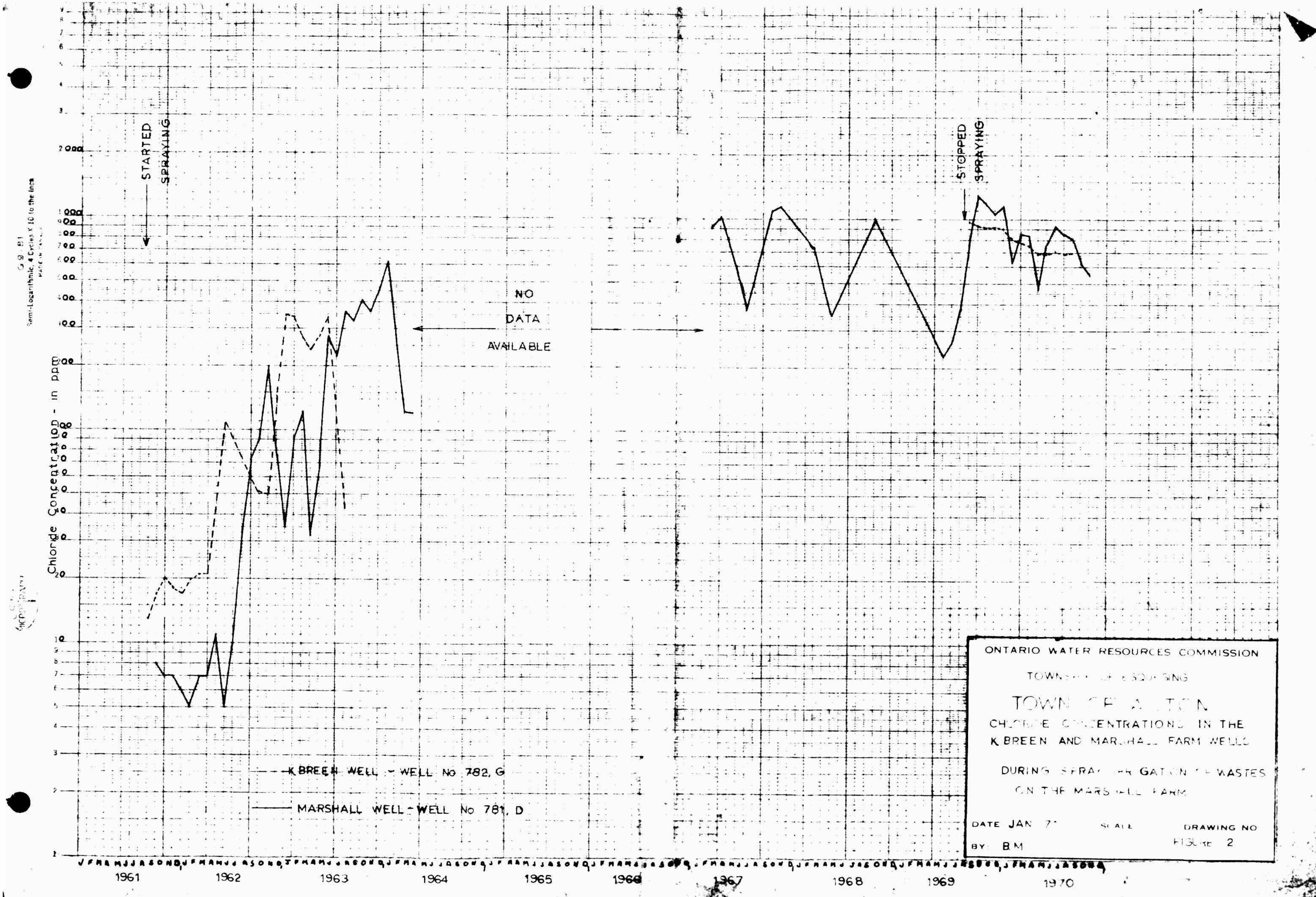
Source of Data - District Engineers Branch,
Division of Sanitary Engineering, OWRC.

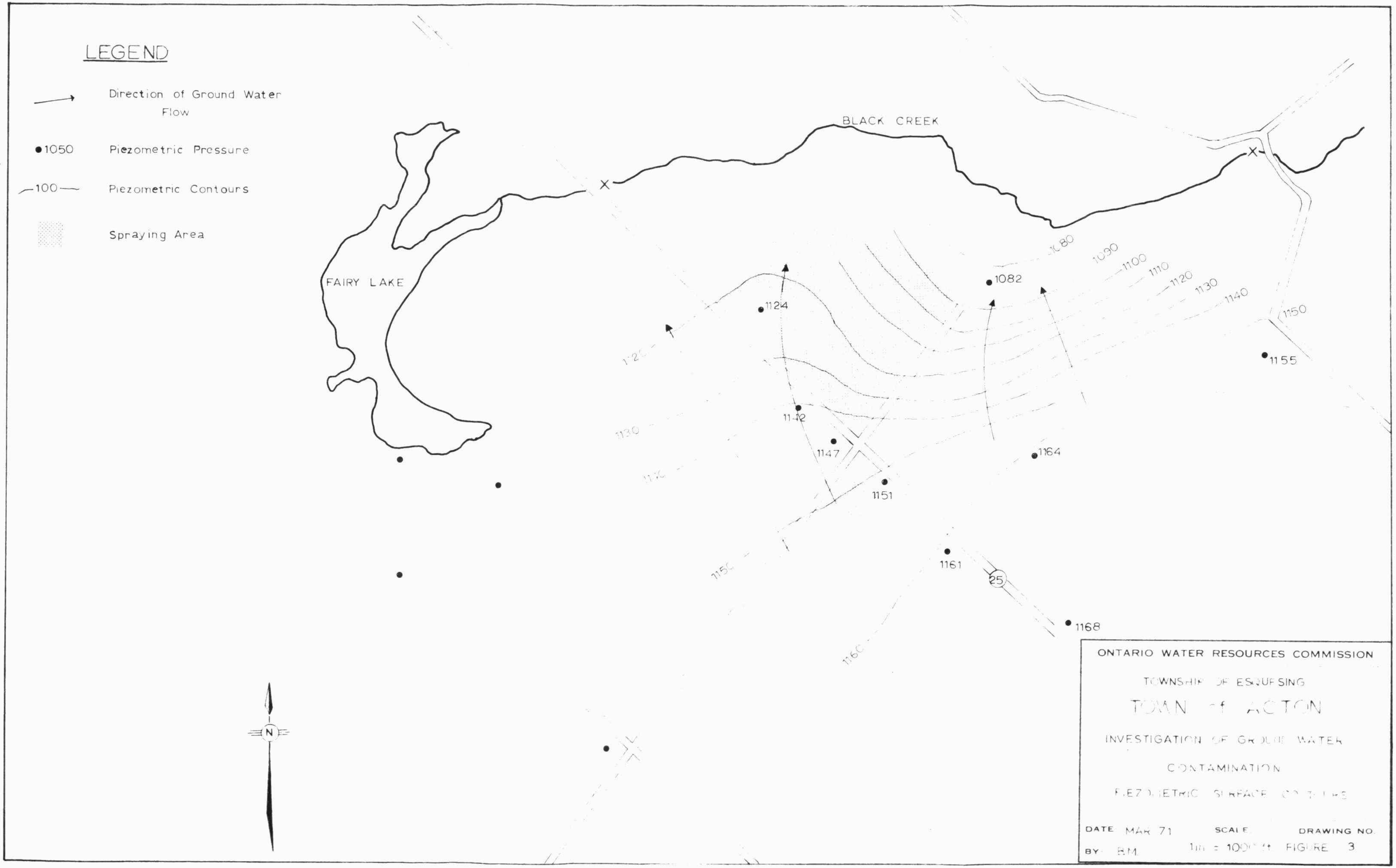
Table 5. Chloride Concentrations in the South Springs.

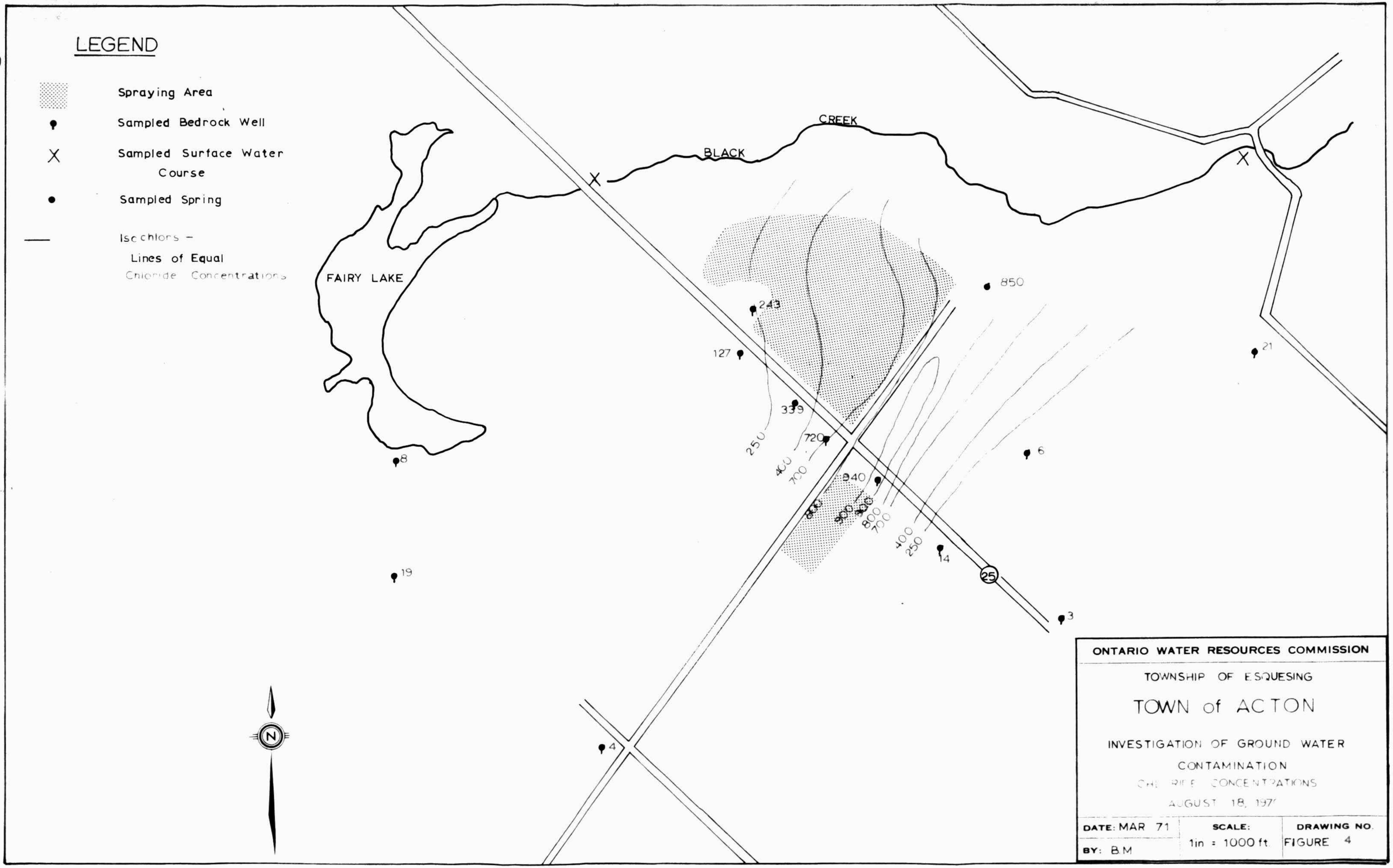
Date	Concentration (ppm)
July 13, 1955	11
March 20, 1956	255
December 2, 1957	788
December 31, 1957	770
July 15, 1958	620
December 15, 1958	1,192
July 28, 1959	715
December 18, 1959	1,072
July 12, 1960	550
December 17, 1960	600
July 20, 1961	600
December 20, 1961	800
July 20, 1962	650
December 10, 1962	750
December 18, 1969	882
July, 1970	883
November 15, 1970	780

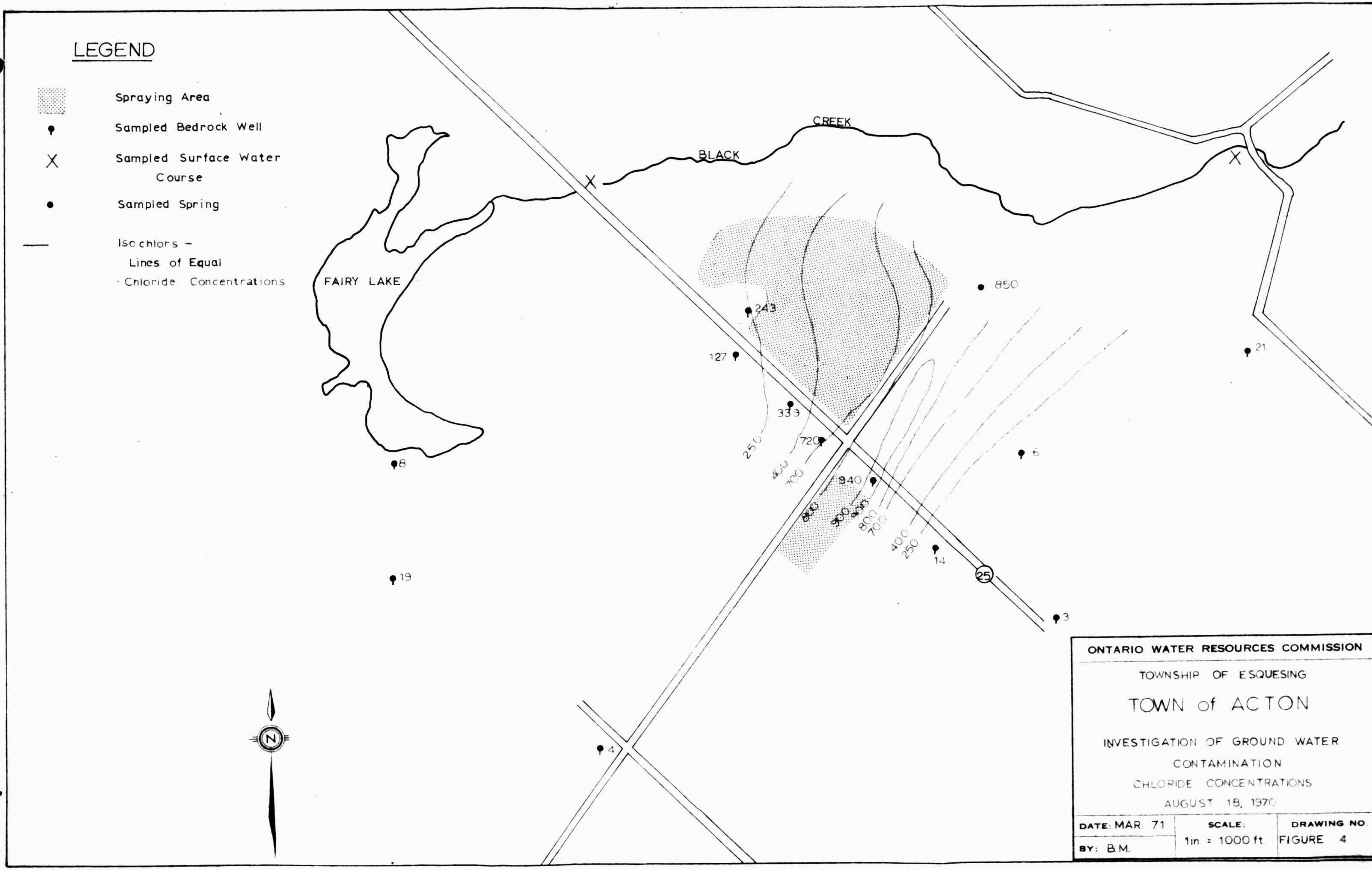
Source of Data - Division of Sanitary Engineering, OWRC.

FIGURES


Chloride Concentration - in ppm
STARTED SPRAYING
STOPPED SPRAYING
NO DATA AVAILABLE
K BREEN WELL - WELL No 782, G
MARSHALL WELL - WELL No 781, D
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
ONTARIO WATER RESOURCES COMMISSION
DATE JAN 7
SCALE
DRAWING NO
BY: B.M
FIGURE 2


LEGEND
Direction of Ground Water Flow
●1050 Piezometric Pressure
—100— Piezometric Contours
Spraying Area
FAIRY LAKE
BLACK CREEK
1080
1090
1100
1110
1120
1130
1140
1150
1082
1124
1155
1142
1147
1151
1164
1161
1168
1130
1150
25
N
ONTARIO WATER RESOURCES COMMISSION
TOWNSHIP OF ESQUESING
TOWN of ACTON
INVESTIGATION OF GROUND WATER
CONTAMINATION
PIEZOMETRIC SURFACE CONTOURS
DATE MAR 71
SCALE 1in = 1000 ft
DRAWING NO. FIGURE 3
BY B.M.


LEGEND
Spraying Area
Sampled Bedrock Well
Sampled Surface Water Course
Sampled Spring
Isochlors – Lines of Equal Chloride Concentrations
FAIRY LAKE
BLACK
CREEK
850
243
127
339
720
840
21
6
8
19
14
3
4
25
250
400
700
800
900
N
ONTARIO WATER RESOURCES COMMISSION
TOWNSHIP OF ESQUESING
TOWN of ACTON
INVESTIGATION OF GROUND WATER CONTAMINATION
CONCENTRATIONS
AUGUST 18,
DATE: MAR 71
BY: B.M
SCALE: 1in = 1000 ft.
DRAWING NO. FIGURE 4



ONTARIO WATER RESOURCES COMMISSION

TOWNSHIP OF ESQUESING

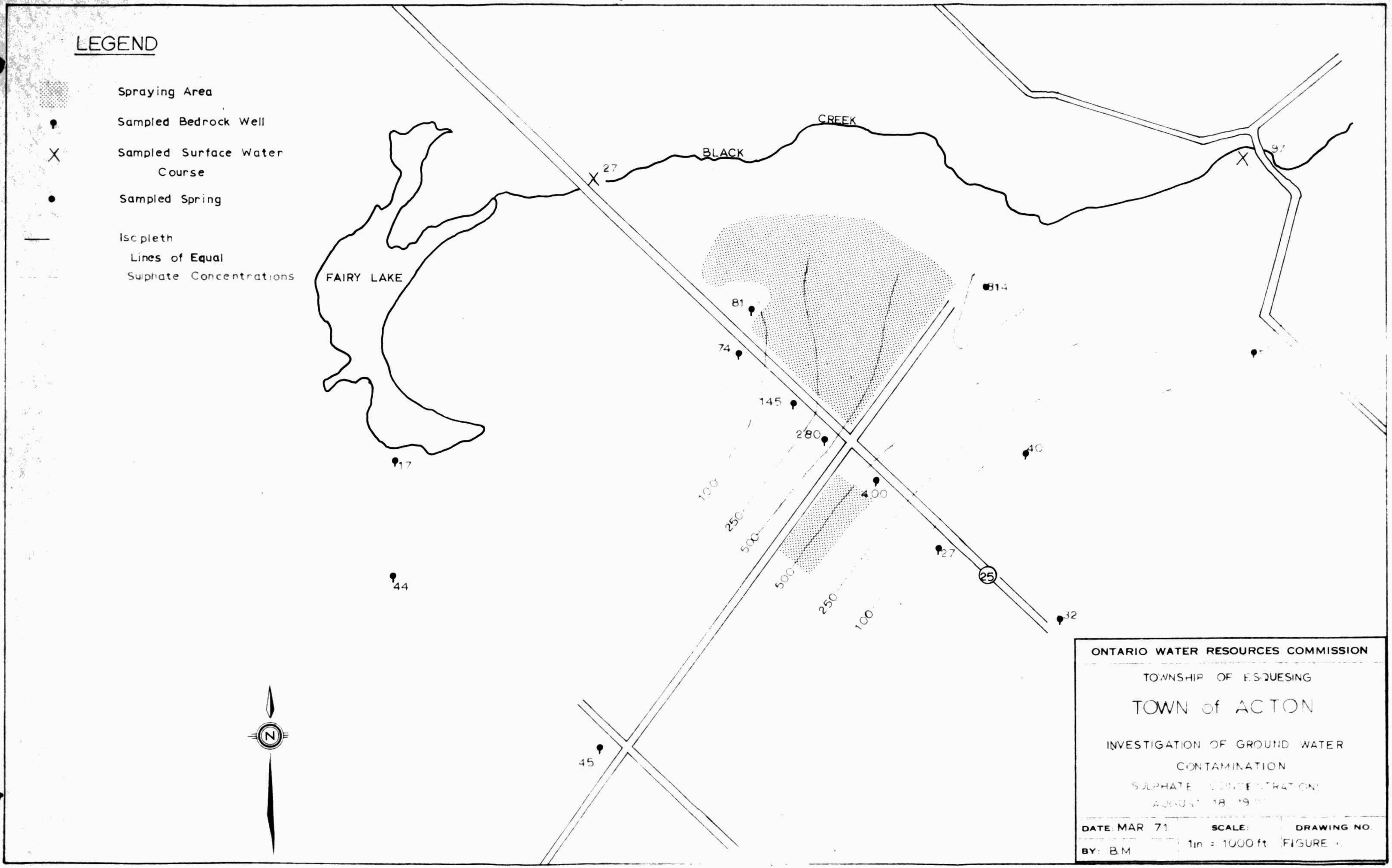
TOWN of ACTON

INVESTIGATION OF GROUND WATER CONTAMINATION

CHLORIDE CONCENTRATIONS

AUGUST 18, 1970

DATE: MAR. 71	SCALE: 1in = 1000 ft	DRAWING NO. FIGURE 4
BY: B.M.		



LEGEND
Spraying Area
Sampled Bedrock Well
Sampled Surface Water Course
Sampled Spring
Iscpleth Lines of Equal Sulphate Concentrations
FAIRY LAKE
BLACK
CREEK
27
97
814
81
74
145
280
400
40
17
44
27
32
45
100
250
500
500
250
100
25
N
ONTARIO WATER RESOURCES COMMISSION
TOWNSHIP OF ESQUESING
TOWN of ACTON
INVESTIGATION OF GROUND WATER CONTAMINATION
DATE: MAR 71
SCALE:
DRAWING NO.
BY: B.M
1in = 1000 ft
FIGURE

G8-32
Triangular - Co - Ordinate
MADE IN CANADA

ONTARIO WATER RESOURCES COMMISSION

PIPER PLOT OF

SAMPLES COLLECTED ON

AUGUST 18, 1970

AT ACTON

DATE: MAR 71

BY: B.M.

SCALE:

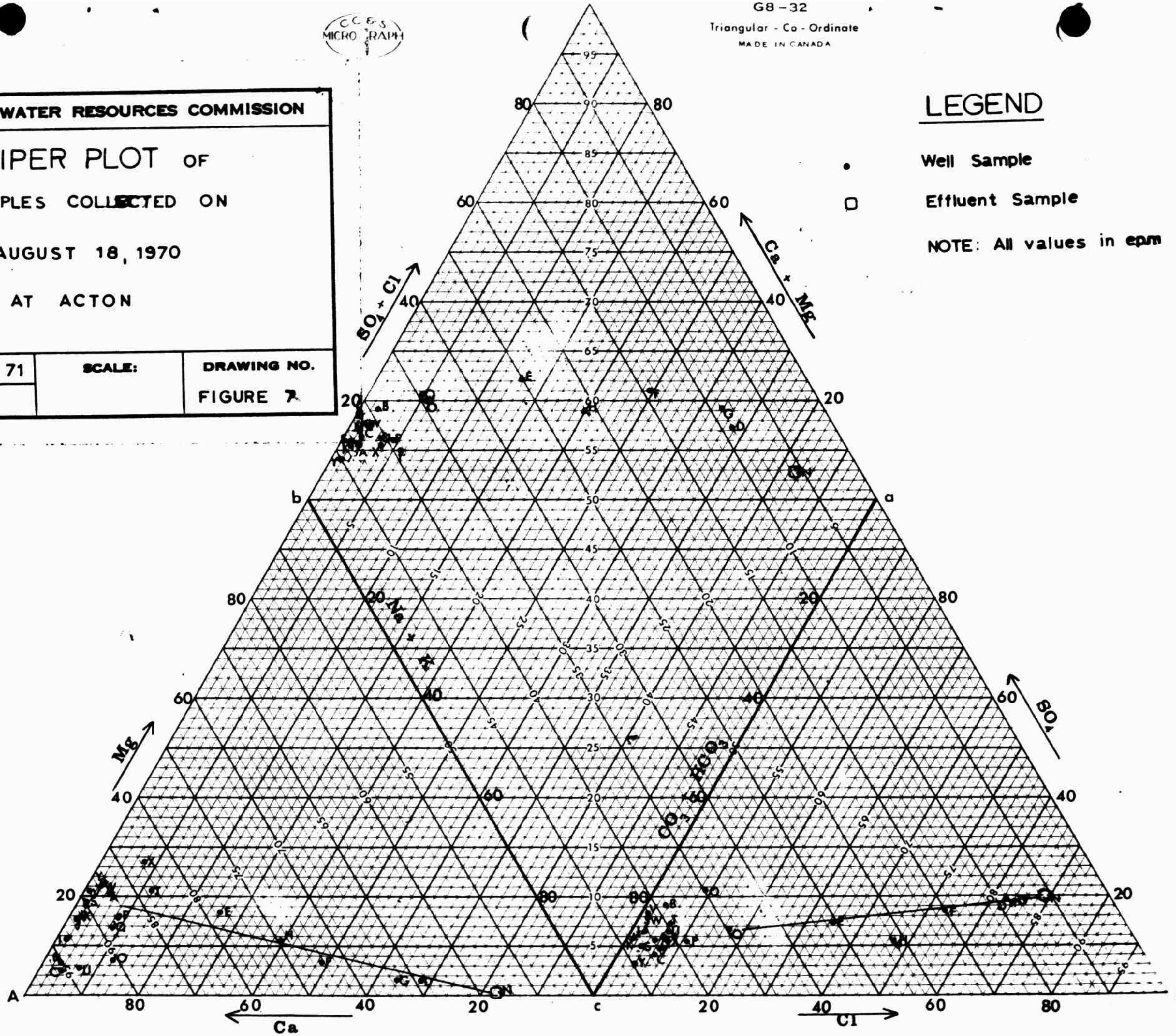
DRAWING NO.
FIGURE 7

LEGEND

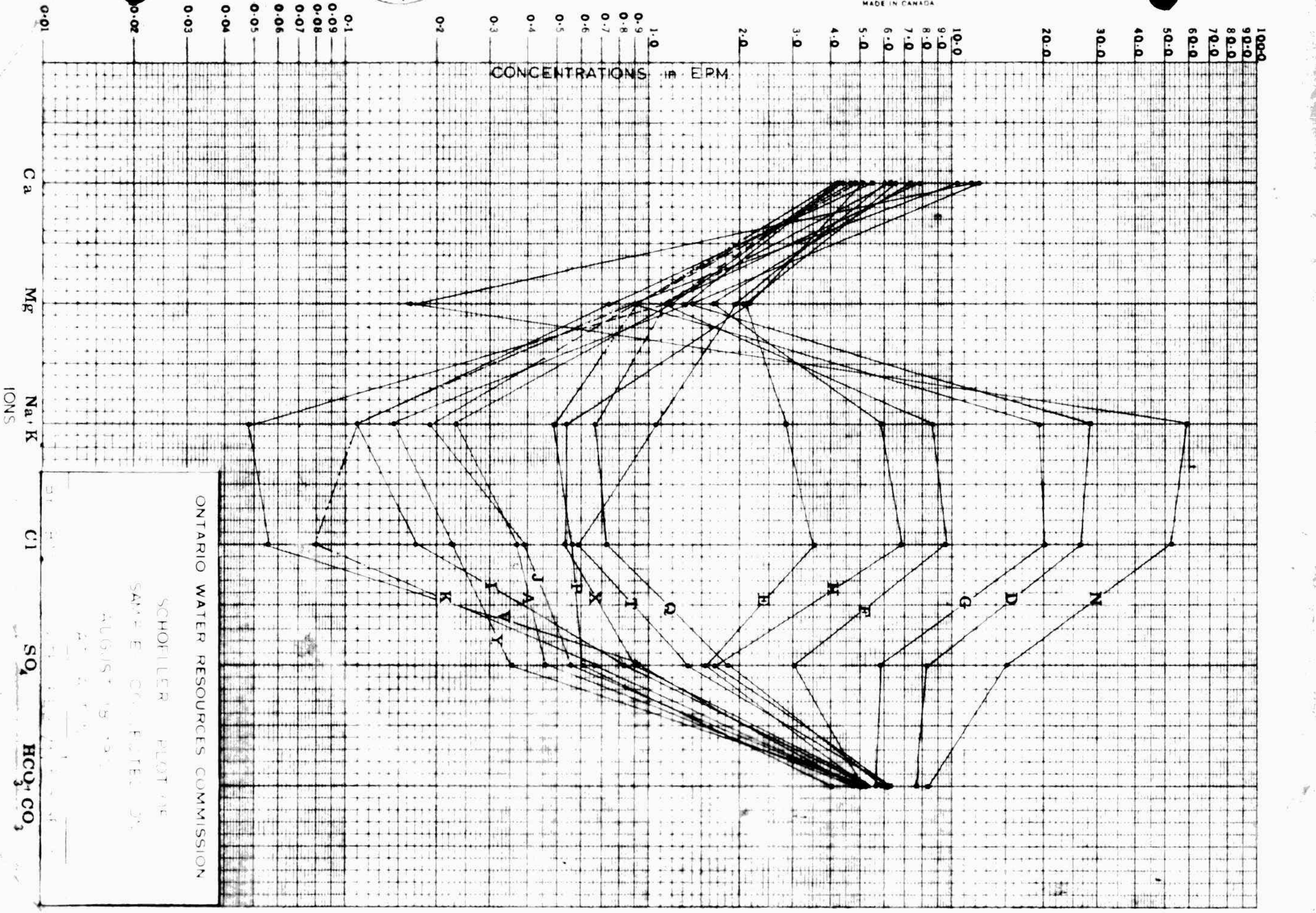
• Well Sample

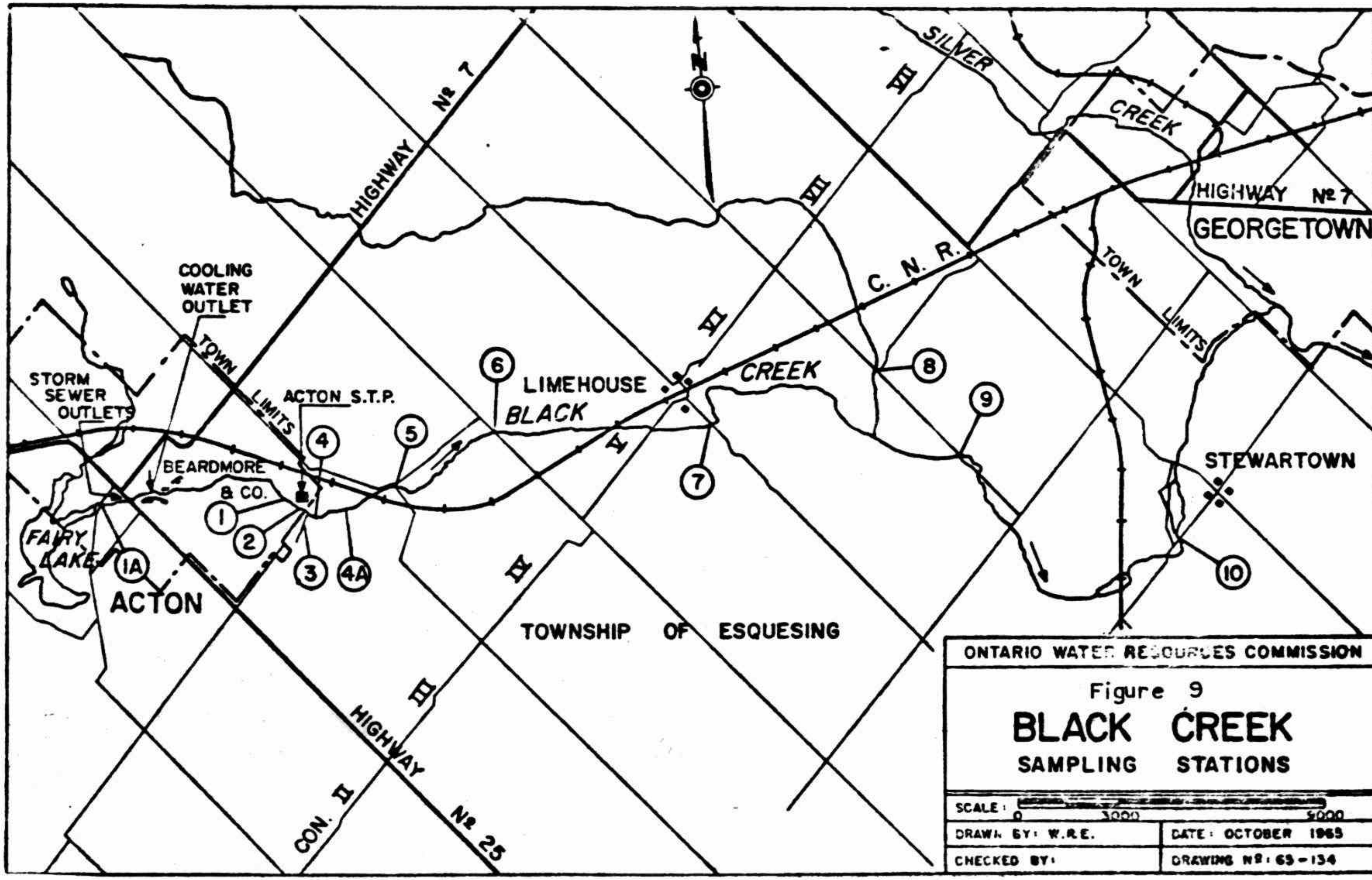
▢ Effluent Sample

NOTE: All values in epm



G9-61
Semi-Logarithmic, 4 Cycles X 10 to the inch
MADE IN CANADA





ONTARIO WATER RESOURCES COMMISSION

Figure 9

BLACK CREEK

SAMPLING STATIONS

SCALE: 0 3000 6000	
DRAWN BY: W.R.E.	DATE: OCTOBER 1965
CHECKED BY:	DRAWING Nº: 65-134

ESQUESING
Acton
Golf Course
Race Course
FAIRY LAKE
BLACK CREEK
PRIMARY SPRAY AREA
SOUTH SPRING
MARSHALL FARM SPRAY AREA
7
25
873
946, S
798, A
920 U
2, M
3, N
918, P
912
917
911
919
1, L
793
696, C
706
695, B
857, H
5, E
854, T
783 F
782 G
779
781D
780 J
776
853
855, K
856, I
785, Y
784
689, X
682, W
684
680, V
1225
1200
1175
1150
1125
1100
1151
LEGEND
Drilled Well in Bedrock
176, D Sampled Location
Swamp
ONTARIO WATER RESOURCES COMMISSION
HALTON COUNTY
TOWN OF ACTON
INVESTIGATION OF GROUND WATER CONTAMINATION
WELL AND SAMPLING LOCATIONS
DATE: DEC 70
BY: B.M.
SCALE: 1in.= 1000 ft.
DRAWING NO. FIGURE 1